



Intel[®] 6700PXH 64-bit PCI Hub

Thermal/Mechanical Design Guidelines

August 2004



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Revision History

Revision Number	Description	Date
-001	Initial release	Jul 2004
-002	Added "reference thermal solution rails to PXH package" footprint drawing in Section 6.5	Aug 2004
-003	Removed inaccurate text in three graphics	Sep 2004



1 Introduction

As the complexity of computer systems increases, so do the power dissipation requirements. Care must be taken to ensure that the additional power is properly dissipated. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heatsinks.

The goals of this document are to:

- Outline the thermal and Mechanical operating limits and specifications for the Intel® 6700PXH 64-bit PCI Hub component.
- Describe a reference thermal solution that meets the specification of Intel® 6700PXH 64-bit PCI Hub component.

Properly designed thermal solution provides adequate cooling to maintain the PXH component die temperatures at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the PXH component die temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics is through careful chassis design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

This document addresses thermal design and specifications for the Intel® 6700PXH 64-bit PCI Hub components only. For thermal design information on other chipset components, refer to the respective component datasheet.

Unless otherwise specified, the term “PXH” refers to the Intel® 6700PXH 64-bit PCI Hub.

1.1 Definition of Terms

BGA	Ball grid array. A package type, defined by a resin-fiber substrate, onto which a die is mounted, bonded and encapsulated in molding compound. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
BLT	Bond line thickness. Final settled thickness of the thermal interface material after installation of heatsink.
MCH	Memory controller hub. The chipset component that contains the processor interface, the memory interface, and the hub interface.
PXH	Intel® 6700PXH 64-bit PCI Hub. The chipset component that performs PCI bridging functions between the PCI Express* interface and the PCI Bus. It contains two PCI bus interfaces that can be independently configured to operate in PCI (33 or 66 MHz) or PCI-X mode 1 (66, 100, or 133 MHz), for either 32 or 64 bit PCI devices.

$T_{\text{case_max}}$	Maximum die temperature allowed. This temperature is measured at the geometric center of the top of the package die.
$T_{\text{case_min}}$	Minimum die temperature allowed. This temperature is measured at the geometric center of the top of the package die.
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the chipset can dissipate.

1.2 Reference Documents

The reader of this specification should also be familiar with material and concepts presented in the following documents:

- *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 R (ICH5R) Datasheet*
- *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 R (ICH5R) Thermal Design Guide*
- *Intel® 6700PXH 64-bit PCI Hub (PXH) Thermal/Mechanical Design Guide*
- *Intel® 6700PXH 64-bit PCI Hub (PXH) Datasheet*
- *Intel® 6700PXH 64-bit PCI Hub (PXH) Specification Update*
- *Intel® 6300ESB I/O Controller Hub Thermal and Mechanical Design Guide*
- *Intel® 6300ESB I/O Controller Hub Datasheet*
- *Intel® 6300ESB I/O Controller Hub (ICH) Specification Update*
- *BGA/OLGA Assembly Development Guide*
- Various system thermal design suggestions (<http://www.formfactors.org>)

Note: Unless otherwise specified, these documents are available through your Intel field sales representative. Some documents may not be available at this time.

2 Packaging Technology

The Intel® 6700PXH 64-bit PCI Hub component uses a 31 mm x 31 mm, 8-layer FC-BGA package (see Figure 2-1, Figure 2-2, and Figure 2-3).

Figure 2-1. Intel® 6700PXH 64-bit PCI Hub Package Dimensions (Top View)

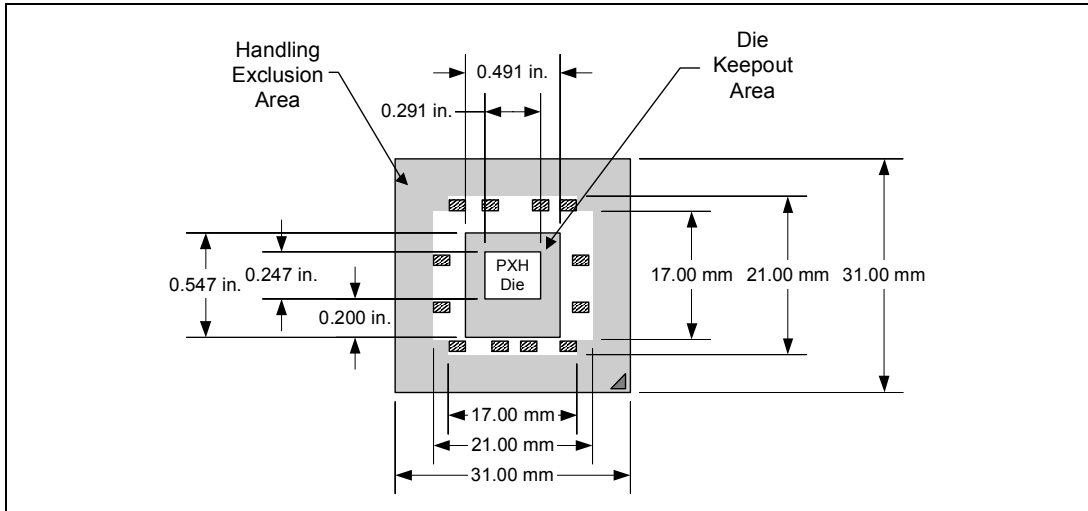


Figure 2-2. Intel® 6700PXH 64-bit PCI Hub Package Dimensions (Side View)

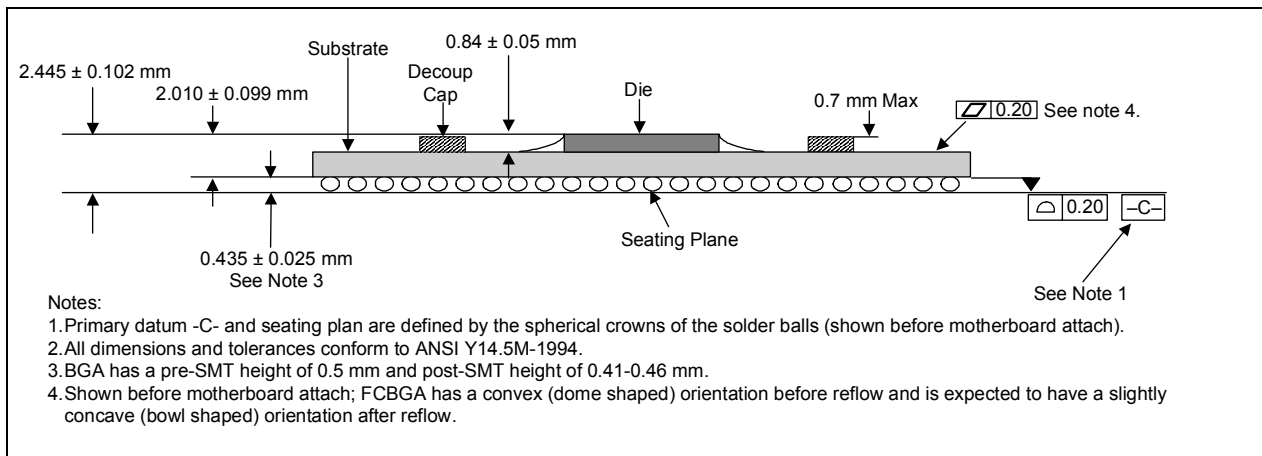
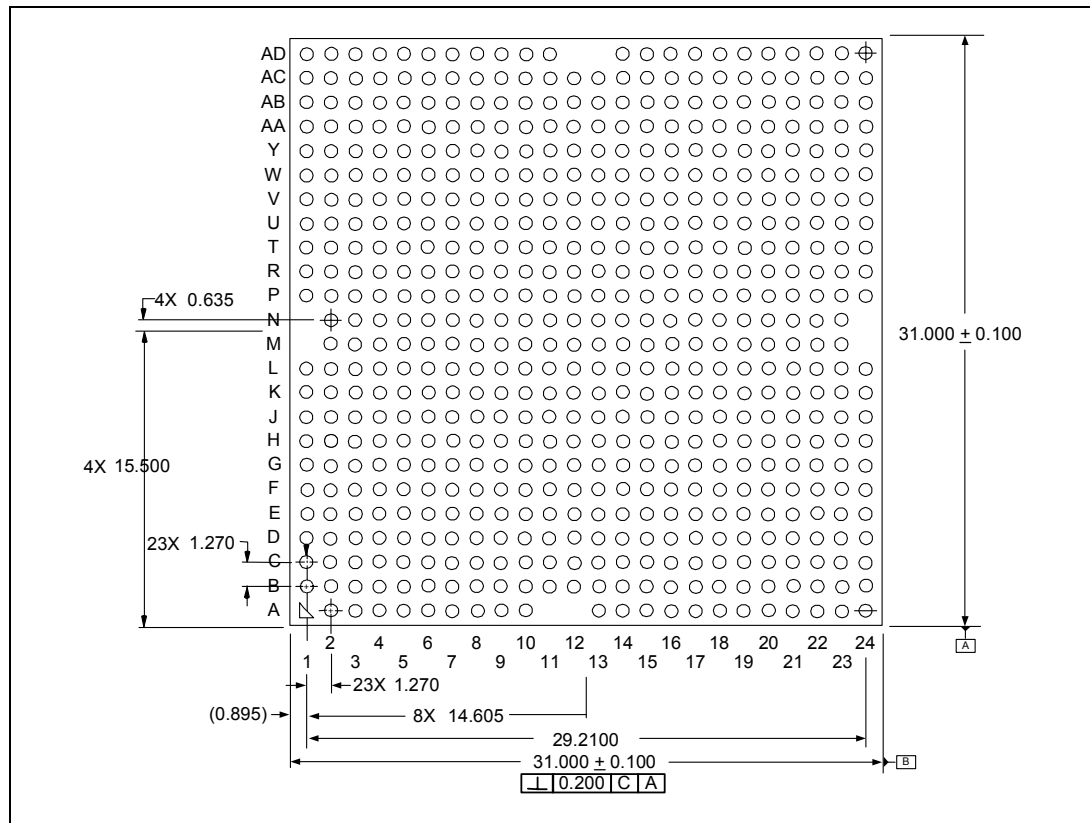


Figure 2-3. Intel® 6700PXH 64-bit PCI Hub Package Dimensions (Bottom View)

**NOTES:**

1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1994.

2.1 Package Mechanical Requirements

The PXH package has an exposed bare die, which is capable of sustaining a maximum static normal load of 15-lbf. The package is NOT capable of sustaining a dynamic or static compressive load applied to any edge of the bare die. These mechanical load limits must not be exceeded during heatsink installation, mechanical stress testing, standard shipping conditions and/or any other use condition.

Notes

1. The heatsink attach solutions must not include continuous stress onto the chipset package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.
2. These specifications apply to uniform compressive loading in a direction perpendicular to the bare die/IHS top surface.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.



3 Thermal Specifications

3.1 Thermal Design Power (TDP)

Analysis indicates that real applications are unlikely to cause the PXH component to consume maximum power dissipation for sustained time periods. Therefore, in order to arrive at a more realistic power level for thermal design purposes, Intel characterizes power consumption based on known platform benchmark applications. The resulting power consumption is referred to as the Thermal Design Power (TDP). TDP is the target power level that the thermal solutions should be designed to. TDP is not the maximum power that the chipset can dissipate.

For TDP specifications, see Table 3-1 for the PXH component. Flip chip ball grid array (FC-BGA) packages have poor heat transfer capability into the board and have minimal thermal capability without a thermal solution. Intel recommends that system designers plan for a heatsink when using the PXH component.

3.2 Die Case Temperature Specifications

To ensure proper operation and reliability of the PXH component, the die temperatures must be at or between the maximum/minimum operating temperature ranges as specified in Table 3-1 Table 3-1 Table 3-1. System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to Chapter 5 for guidelines on accurately measuring package die temperatures.

Table 3-1. Intel® 6700PXH 64-bit PCI Hub Thermal Specifications

Parameter	Value	Notes
T _{case_max}	105°C	
T _{case_min}	5°C	
TDP Segment A @ 66 MHz and Segment B @ 66 MHz	9.0 watts	
TDP Segment A @ 100 MHz and Segment B @ 100 MHz	8.9 watts	
TDP Segment A @ 133 MHz and Segment B @ 133 MHz	8.6 watts	
TDP Segment A @ 66 MHz and Segment B @ 100 MHz	8.9 watts	
TDP Segment A @ 66 MHz and Segment B @ 133 MHz	8.8 watts	
TDP Segment A @ 100 MHz and Segment B @ 133 MHz	8.7 watts	

Note: These specifications are based on silicon characterization, however, they may be updated as further data becomes available.





4 Thermal Simulation

Intel provides thermal simulation models of the Intel® 6700PXH 64-bit PCI Hub component and associated user's guides to aid system designers in simulating, analyzing, and optimizing their thermal solutions in an integrated, system-level environment. The models are for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tool "FLOTHERM"* (version 3.1 or higher) by Flomerics, Inc. These models are also available in IcePak* format. Contact your Intel field sales representative to order the Icepak thermal model and user's guide.



5 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques to measure the PXH die temperatures. Section 5.1 provides guidelines on how to accurately measure the PXH die temperatures.

5.1 Die Case Temperature Measurements

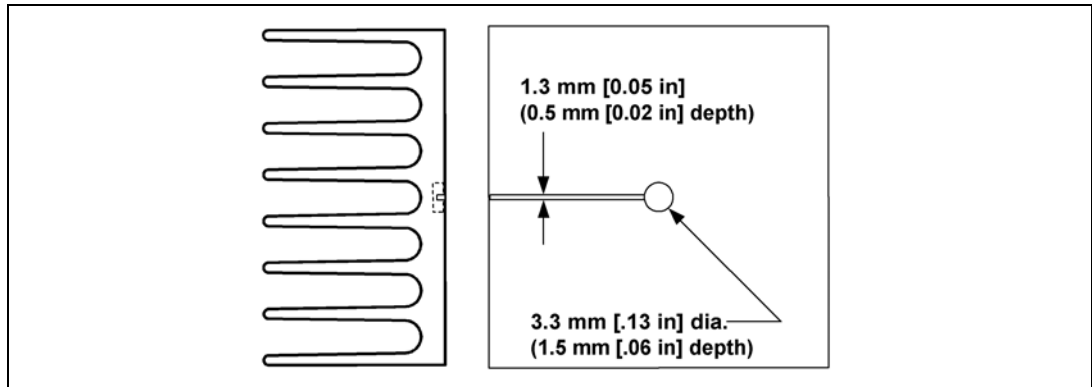
To ensure functionality and reliability, the T_{case} of the PXH must be maintained at or between the maximum/minimum operating range of the temperature specification as noted in Table 3-1. The surface temperature at the geometric center of the die corresponds to T_{case} . Measuring T_{case} requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce errors in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, conduction through thermocouple leads, or contact between the thermocouple cement and the heatsink base (if a heatsink is used). For maximum measurement accuracy, only the 0° thermocouple attach approach is recommended.

5.1.1 Zero Degree Angle Attach Methodology

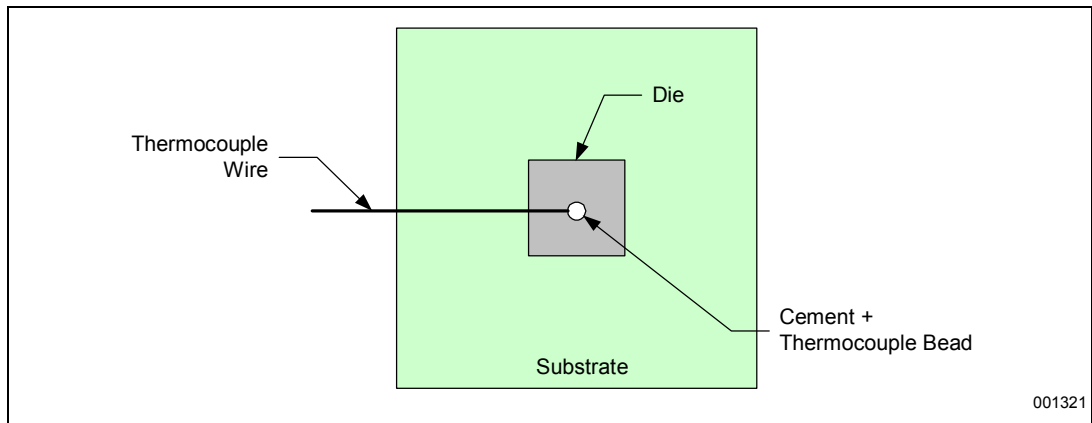
1. Mill a 3.3 mm (0.13 in.) diameter and 1.5 mm (0.06 in.) deep hole centered on the bottom of the heatsink base.
2. Mill a 1.3 mm (0.05 in.) wide and 0.5 mm (0.02 in.) deep slot from the centered hole to one edge of the heatsink. The slot should be parallel to the heatsink fins (see Figure 5-1).
3. Attach thermal interface material (TIM) to the bottom of the heatsink base.
4. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
5. Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the die using a high thermal conductivity cement. During this step, ensure no contact is present between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. **It is critical that the thermocouple bead makes contact with the die** (see Figure 5-2).
6. Attach heatsink assembly to the PXH and route thermocouple wires out through the milled slot.

Figure 5-1. Zero Degree Angle Attach Heatsink Modifications



NOTE: Not to scale.

Figure 5-2. Zero Degree Angle Attach Methodology (Top View)



NOTE: Not to scale.

6 Reference Thermal Solution

Intel has developed one reference thermal solution to meet the cooling needs of the PXH component under operating environments and specifications defined in this document. This chapter describes the overall requirements for the reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need attached thermal solutions, depending on your specific system local-ambient operating conditions.

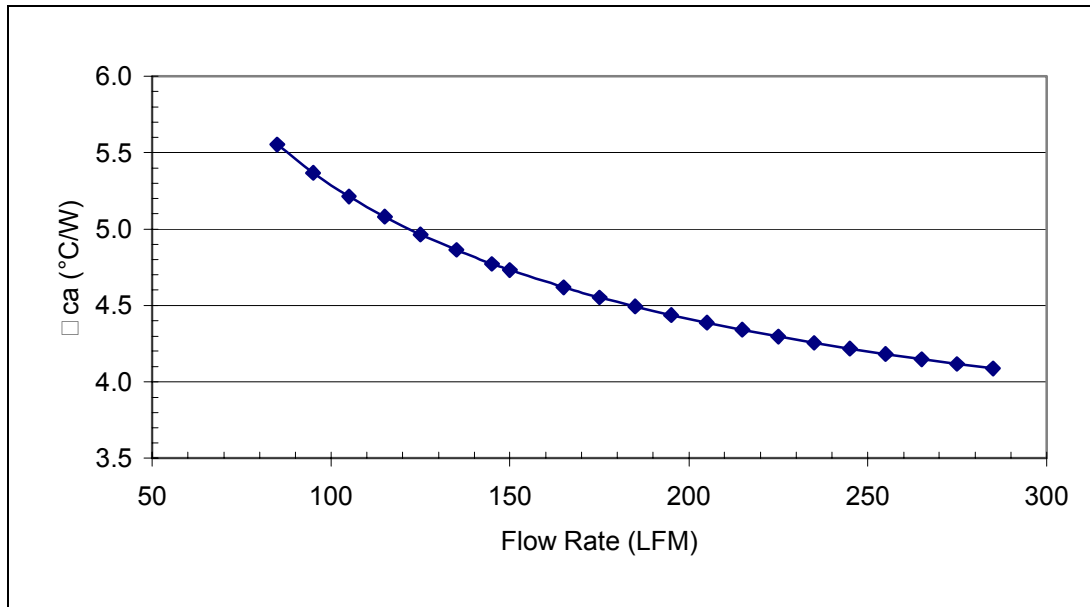
6.1 Operating Environment

The PXH reference thermal solution was designed assuming a maximum local-ambient temperature of 55°C. The minimum recommended airflow velocity through the cross section of the heatsink fins is 200 linear feet per minute (lfm). The approaching airflow temperature is assumed to be equal to the local-ambient temperature. The thermal designer must carefully select the location to measure airflow to obtain an accurate estimate. These local-ambient conditions are based on a 35°C external-ambient temperature at sea level. (External-ambient refers to the environment external to the system.)

6.2 Heatsink Performance

Figure 6-1 depicts the measured thermal performance of the reference thermal solution versus approach air velocity. Since this data was measured at sea level, a correction factor would be required to estimate thermal performance at other altitudes.

Figure 6-1. Reference Heatsink Measured Thermal Performance Versus Approach Velocity

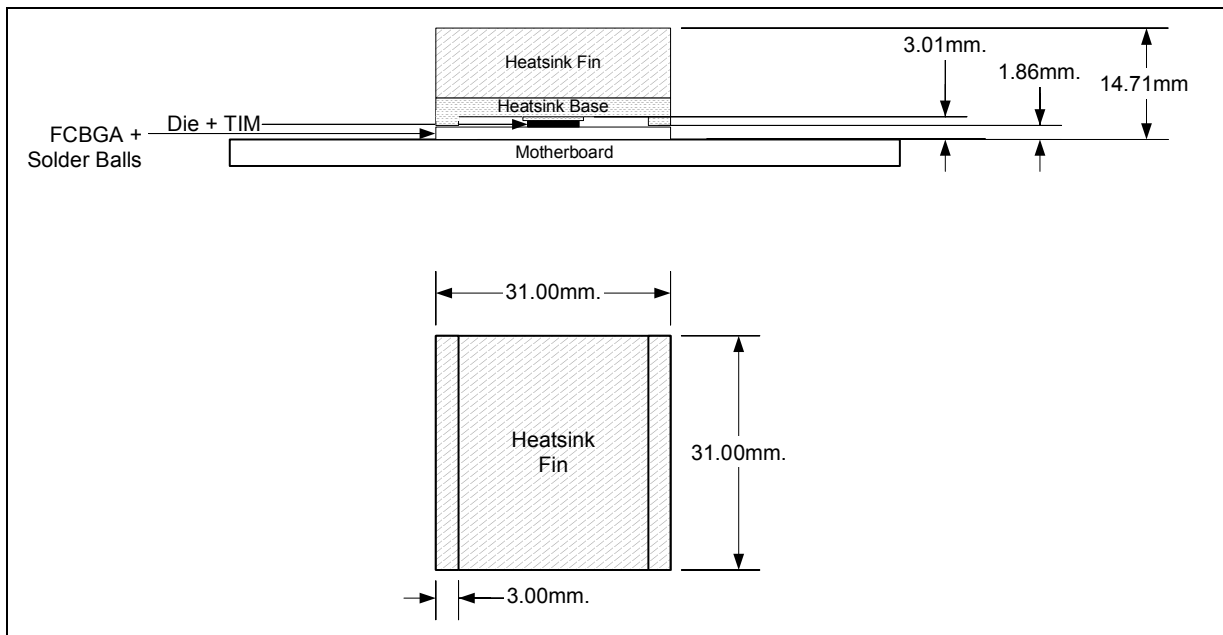


6.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the PXH thermal solution are shown in Figure 6-2.

When using heatsinks that extend beyond the PXH reference heatsink envelope shown in Figure 6-2, any motherboard components placed between the heatsink and motherboard cannot exceed 2.40 mm (0.094 in.) in height.

Figure 6-2. Torsional Clip Heatsink Volumetric Envelope for the Intel® 6700PXH 64-bit PCI Hub Chipset Component



6.4 Board-Level Components Keepout Dimensions

The locations of hole pattern and keepout zones for the reference thermal solution are shown in Figure 6-3 and Figure 6-4.

6.5 Torsional Clip Heatsink Thermal Solution Assembly

The reference thermal solution for the PXH component is a passive extruded heatsink with thermal interface. It is attached using a clip with each end hooked through an anchor soldered to the board. Figure 6-5 shows the reference thermal solution assembly and associated components. Figure 6-6 shows the position of the heatsink rails relative to the PXH package top surface.

Full mechanical drawings of the thermal solution assembly and the heatsink clip are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

6.5.1 Heatsink Orientation

Since this solution is based on a unidirectional heatsink, mean airflow direction must be aligned with the direction of the heatsink fins.

Figure 6-5. Torsional Clip Heatsink Assembly

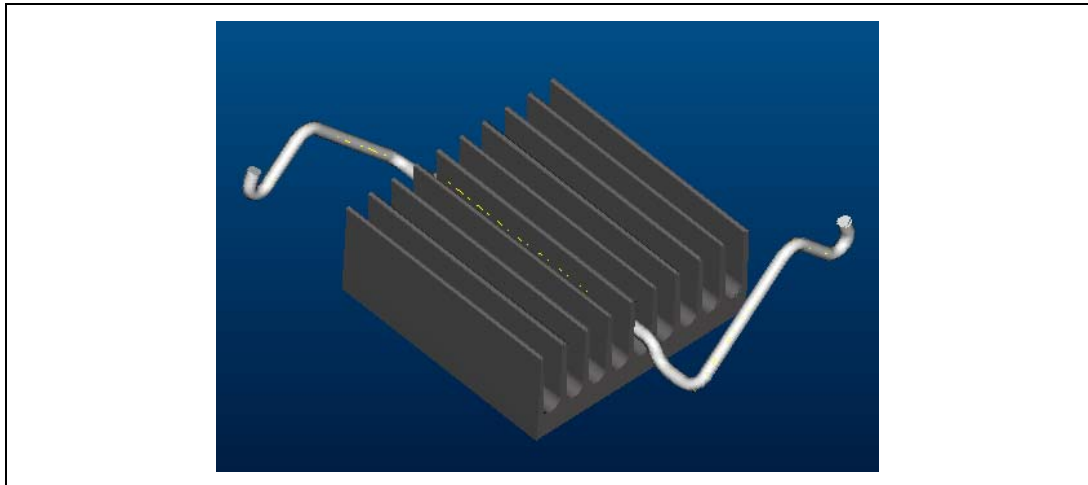
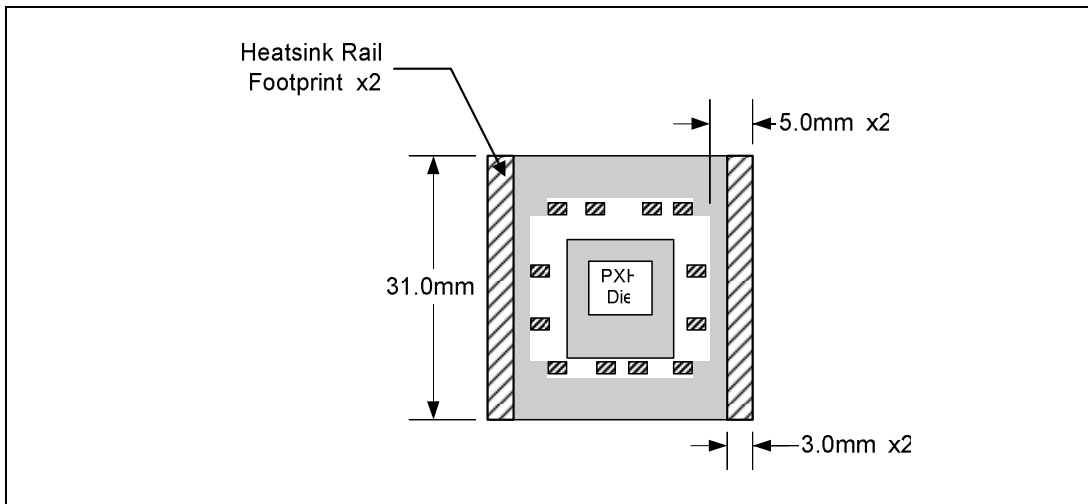


Figure 6-6 Heatsink Rails to PXH Package Footprint



6.5.2 Extruded Heatsink Profiles

The reference torsional clip heatsink uses an extruded heatsink for cooling the PXH component. Figure 6-7 shows the heatsink profile. Appendix A lists a supplier for this extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available. Full mechanical drawing of this heatsink is provided in Appendix B.

6.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.5.4 Thermal Interface Material

A thermal interface material provides improved conductivity between the die and heatsink. The reference thermal solution uses Chomerics* T-710, 0.127 mm (0.005 in.) thick, 8 mm x 8 mm square.

Note: Unflowed or “dry” Chomerics* T710 has a material thickness of 0.005 inch. The flowed or “wet” Chromerics T710 has a material thickness of ~0.0025 inch after it reaches its phase change temperature.

6.5.4.1 Effect of Pressure on TIM Performance

As mechanical pressure increases on the TIM, the thermal resistance of the TIM decreases. This phenomenon is due to the decrease of the bond line thickness (BLT). BLT is the final settled thickness of the thermal interface material after installation of heatsink. The effect of pressure on the thermal resistance of the Chomerics T710 TIM is shown in Table 6-1Table 6-1Table 6-1. The heatsink clip provides enough pressure for the TIM to achieve a thermal conductivity of 0.17°C inch²/W.

Table 6-1. Chomerics* T710 TIM Performance as a Function of Attach Pressure

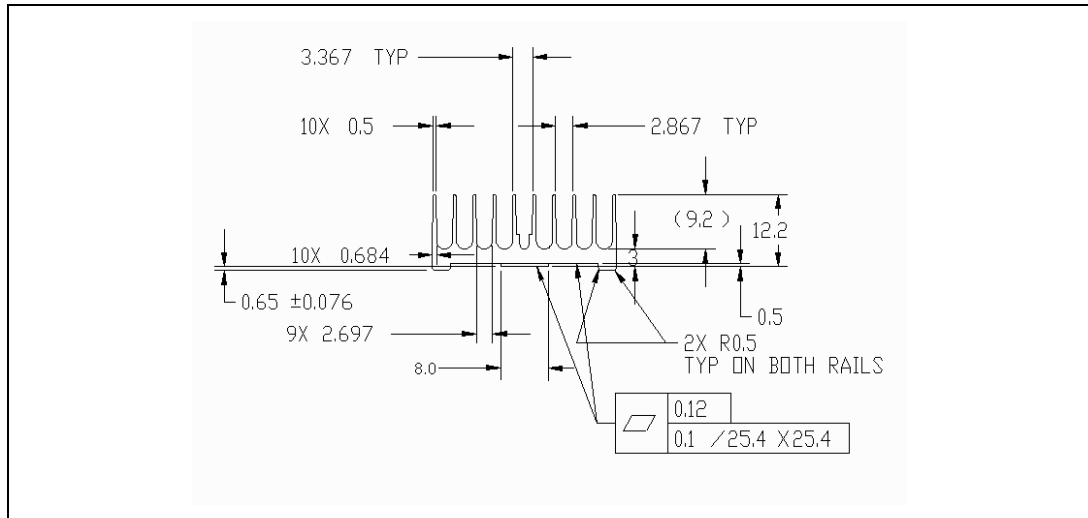
Pressure (psi)	Thermal Resistance (°C × in ²)/W
5	0.37
10	0.30
20	0.21
30	0.17

NOTE: All measured at 50°C.

6.5.5 Heatsink Clip

The reference solution uses a wire clip with hooked ends. The hooks attach to wire anchors to fasten the clip to the board. See Appendix B for a mechanical drawing of the clip.

Figure 6-7. Torsional Clip Heatsink Extrusion Profile



6.5.6 Clip Retention Anchors

For Intel® 6700PXH 64-bit PCI Hub-based platforms that have very limited board space, a clip retention anchor has been developed to minimize the impact of clip retention on the board. It is based on a standard three-pin jumper and is soldered to the board like any common through-hole header. A new anchor design is available with 45° bent leads to increase the anchor attach reliability over time. See Appendix A for the part number and supplier information.

6.6 Reliability Guidelines

Each motherboard, heatsink and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. Some general recommendations are shown in Table 6-2Table 6-2Table 6-2.

Table 6-2. Reliability Guidelines

Test ⁽¹⁾	Requirement	Pass/Fail Criteria ⁽²⁾
Mechanical Shock	50 g, board level, 11 msec, 3 shocks/axis.	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 min/axis, 50 Hz to 2000 Hz.	Visual Check and Electrical Functional Test
Temperature Life	85°C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours.	Visual Check
Thermal Cycling	-5°C to +70°C, 500 cycles.	Visual Check
Humidity	85% relative humidity, 55°C, 1000 hours.	Visual Check

NOTES:

1. It is recommended that the above tests be performed on a sample size of at least twelve assemblies from three lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.



A Thermal Solution Component Suppliers

A.1 Torsional Clip Heatsink Thermal Solution

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Heatsink Assembly includes: <ul style="list-style-type: none">Unidirectional Fin HeatsinkThermal Interface MaterialTorsional Clip	C76435-001	CCI/ACK*	Harry Lin (USA) 714-739-5797 hlinack@aol.com Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw
Unidirectional Fin Heatsink (31.0 x 31.0 x 12.2 mm)	C76434-001	CCI/ACK	Harry Lin (USA) 714-739-5797 hlinack@aol.com Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw
Thermal Interface (Chomerics* T-710)	A69230-001	Chomerics* 69-12-22066-T710	Todd Sousa (USA) 360-606-8171 tsousa@parker.com
Heatsink Attach Clip	C17725-001	CCI/ACK	Harry Lin (USA) 714-739-5797 hlinack@aol.com Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw
Solder-Down Anchor	A13494-005	Foxconn* (HB96030-DW)	Julia Jiang (USA) 408-919-6178 juliaj@foxconn.com

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.





B Mechanical Drawings

Table B-1 Table B-1 Table B-1 lists the mechanical drawings included in this appendix.

Table B-1. Mechanical Drawing List

Drawing Description	Figure Number
Torsional Clip Heatsink Assembly Drawing	Figure B-1 Figure B-1
Torsional Clip Heatsink Drawing	Figure B-2 Figure B-2
Torsional Clip Drawing	Figure B-3 Figure B-3

Figure B-1. Torsional Clip Heatsink Assembly Drawing

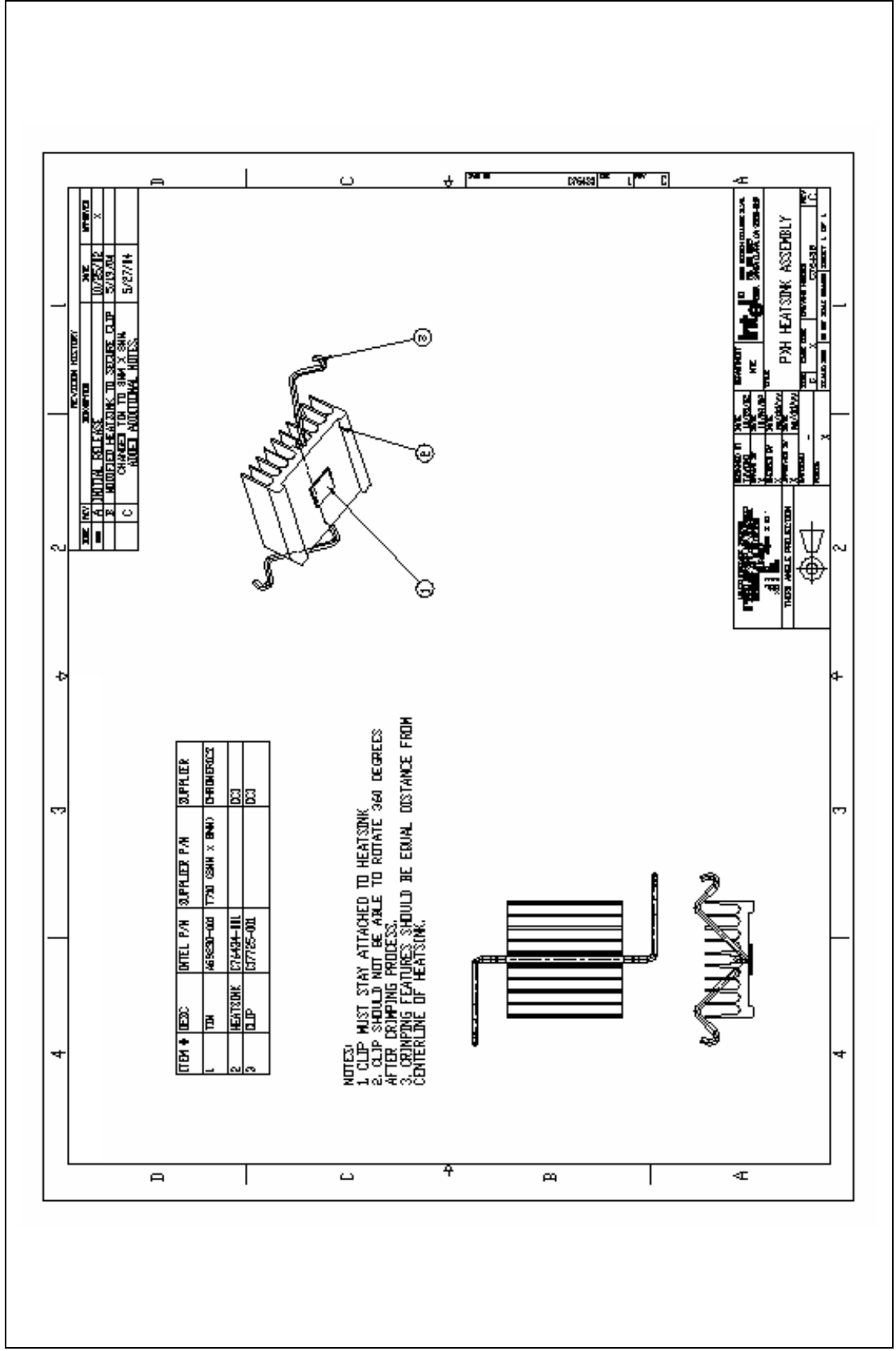


Figure B-2. Torsional Clip Heatsink Drawing

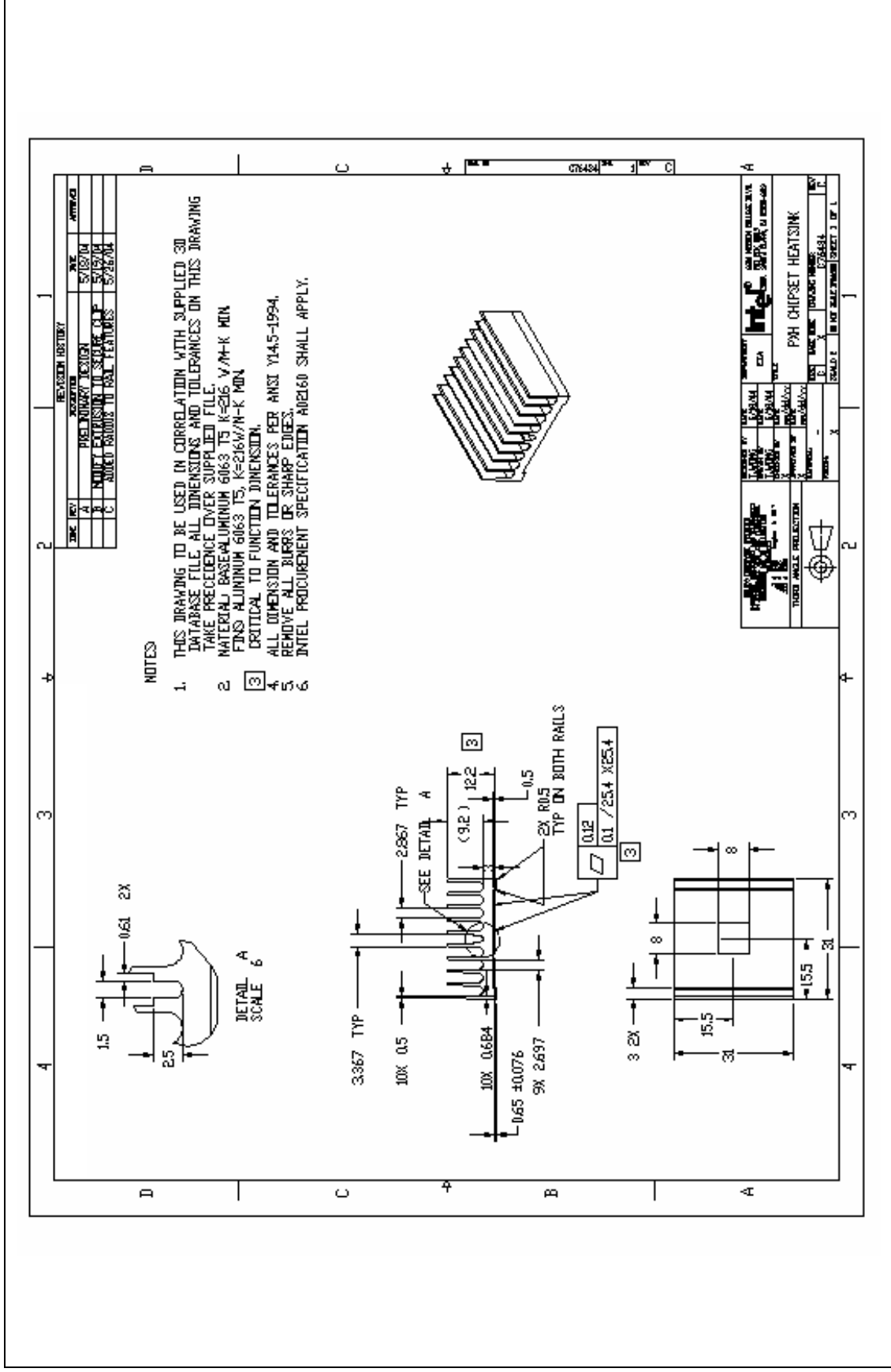
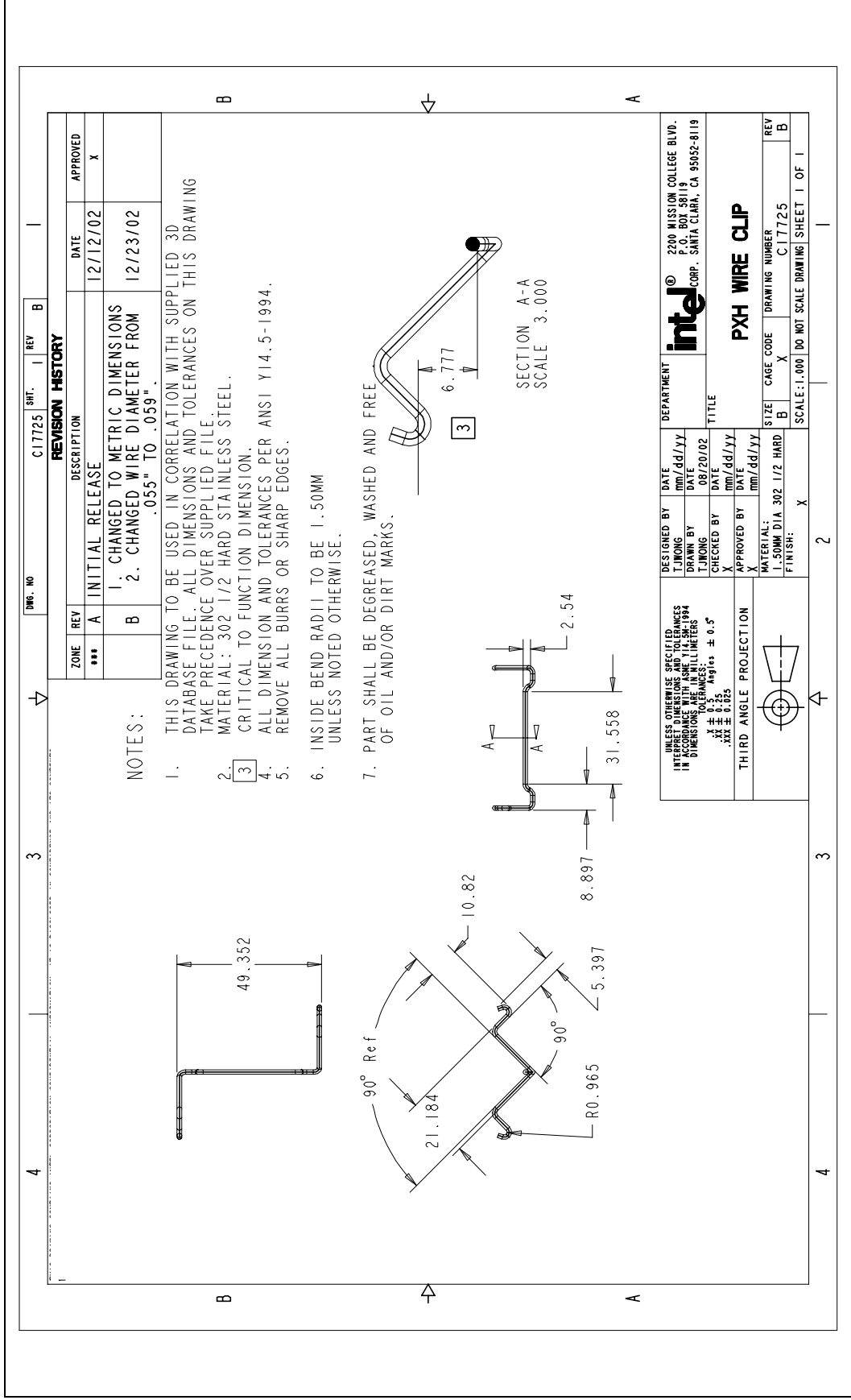


Figure B-3. Torsional Clip Drawing



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